REMARKS

This Amendment is in response to the Office Action dated December 21, 2004. Claims 1-41 are pending. Claims 1-41 are rejected. Accordingly, claims 1-41 remain pending in the present application.

Present Invention

The present invention provides an in-plane angular velocity sensor having two masses that are laterally disposed in the plane and indirectly connected to a frame. The two masses are linked together by a linkage such that they move in opposite directions along Z (i.e., when one mass moves in the +Z direction, the other mass moves in the -Z direction, and vice versa). Here Z is the out-of-plane direction. In-plane angular velocity can be sensed by driving the two masses into Z-directed antiphase oscillation and measuring the angular oscillation amplitude thereby imparted to the frame. Alternatively, in-plane angular velocity can be sensed by driving the frame into angular oscillation about the Z axis and measuring the Z-directed antiphase oscillation amplitude thereby imparted to the two masses.

In a preferred embodiment, the frame, the two masses and the linkage are fabricated from a single Silicon wafer using bulk micromachining (MEMS) technology to form a gyroscope wafer. In a further preferred embodiment, circuitry for driving and sensing motion of elements of the gyroscope wafer is included in a single Silicon wafer to form a reference wafer that is affixed to the gyroscope wafer. In this embodiment, it is also preferred to fabricate a cap wafer from a single Silicon wafer, and affix the cap wafer to the gyroscope wafer such that the gyroscope wafer is sandwiched in between the cap wafer and the reference wafer. In this manner, a hermetic barrier can be formed to protect the elements of the gyroscope wafer from an environment.

Claim Rejections – 35 USC 103

The Examiner states,

3. Claims 1-8, 13-41 are rejected under 35 U.S.C. 103(a) as being unpatentable over Applicant's admitted prior art in view of Shcheglov et al (US 2004/0055380).

Applicant's admitted prior art disclose a process of making MEMS gyroscopic sensor having two masses that are laterally disposed in the device plane and the two masses are moving in opposite directions perpendicular to the device plane (see pages 3-4 in the specification).

Applicant's admitted prior art fails to explicitly show the etching of the subassembly from a gyroscope wafer including the etching steps of reference wafer and cap wafer.

However, in a method of manufacturing gyroscope, Shcheglov et al disclose a process including the steps of etching wafers and bonding together with the deposition of electrode layers as the transducer, wherein photolithographic is performed prior the etching of reactive ion etching (paragraphs 0073-0076).

Shcheglov et al also disclose that gyroscope comprises four masses on a plane and each occupying a separate plane of a supporting frame and the frame is attached to the base plate at a central support in order to increase sensing capability (paragraphs 0025, 0029 and 0084).

4. Claims 9-12 are rejected under 35 U.S.C. (103(a) as being unpatentable over Applicant's admitted prior art in view of Shcheglov et al (US 2004/0055380) as applied to claims 1-8 and 13-41 above, and further in view of Turner et al (6,794,272).

Modified Applicant's admitted prior art discusses above in the paragraph 3 but fail to teach thinning the wafer prior to etching process.

However, in a method of forming integrated circuits, Turner et al teach a thinning process using grinding or CMP process prior to etching in order to efficiently reduce the wafer thickness while minimizing yield loss (col.6, lines 52-57).

Therefore, it would have been obvious to one of ordinary skill in the art at the time of claimed invention to combine Turner et al's teaching into modified Applicant's admitted prior art for efficiently reducing the wafer thickness while minimizing yield loss as taught by Turner et al.

Applicant respectfully disagrees.

Prior Art

1. Admitted Prior Art

Some known in-plane MEMS angular velocity sensors have two proof masses driven into oscillation. For example, US Patent 6,481,283 to Cardarelli teaches an in-plane MEMS sensor. In the coordinates of Cardarelli, the device plane is the YZ plane. In a first embodiment, Cardarelli teaches two masses dithered in the +/- Y direction (i.e., in-plane). Angular velocity about a Z axis leads to X directed Coriolis forces on the two masses. The two masses are

attached to a gimbal rotatable about the Z axis such that X directed forces on the masses provide Z directed torques on the gimbal. The two masses are dithered to have oppositely directed velocities, so the two Coriolis forces provides a net torque on the gimbal about the Z axis. Motion of the gimbal about the Z axis is sensed.

In a second embodiment, Cardarelli teaches two masses dithered in the +/- X direction (i.e., out-of-plane). Angular velocity about a Z axis leads to Y directed Coriolis forces on the two masses. The two masses are attached to a gimbal rotatable about the Z axis such that Y directed forces on the masses provide Z directed torques on the gimbal. The two masses are dithered to have oppositely directed velocities, so the two Coriolis forces provides a net torque on the gimbal about the Z axis. Motion of the gimbal about the Z axis is sensed.

Another known in-plane MEMS angular velocity sensor having two proof masses driven into oscillation is taught in US Patent 6,508,122 to McCall et al. McCall et al. teach an in-plane MEMS sensor having two unconnected masses that are laterally disposed in the device plane and dithered out of phase with respect to each other in this plane direction. For definiteness, let the device plane be the XY plane, and let the dither be in the X direction. The masses oscillate in the Z direction when the sensor is rotated about the Y axis, due to Z-directed Coriolis forces. The Z directed oscillation of the masses is sensed.

The approaches of both Cardarelli and McCall et al. are motivated by a desire to reject "common mode" interference from the measurement of angular velocity. For example, an angular velocity sensor having a single proof mass can register an incorrect reading if subjected to a linear acceleration in the same direction as the Coriolis force to be sensed. With two masses, various arrangements are possible, including those mentioned above, that respond to Coriolis forces but generally do not respond to linear acceleration in the same direction as the Coriolis forces. Typically, such arrangements depend on driving the two masses so that their velocities

are always equal and opposite. Any deviation from a condition of equal and opposite velocities is disadvantageous, since such deviation reduces the desired response to the Coriolis forces, and increases the undesired response to linear acceleration.

However, in practice it is not straightforward to drive two masses with equal and opposite velocities. For example, two nominally identical and identically mounted masses can differ in practice so that actuating these two masses with the same actuation provides velocities which are not equal and opposite. Actuators tend to vary in effectiveness as well, so even if two masses were identical and identically mounted, variation in the actuators connected to the two masses could again provide mass velocities which are not equal and opposite. Similarly, circuitry connected to actuators may not be identical, etc. As a result, known two mass in-plane angular velocity sensors have not fully realized the common mode rejection promised by two mass configurations.

2. Shcheglov - 200455380

Shcheglov discloses an inertial sensor comprising a planar mechanical resonator with embedded sensing and actuation for substantially in-plane vibration and having a central rigid support for the resonator. At least one excitation or torquer electrode is disposed within an interior of the resonator to excite in-plane vibration of the resonator for sensing the motion of the excited resonator. In one embodiment, the planar resonator includes a plurality of slots in an annular pattern; in another embodiment, the planar mechanical resonator comprises four masses; each embodiment having a simple degenerate pair of in-plane vibration modes.

Argument

Applicant submits that these references do not disclose or suggest either singly or in

combination the present invention as recited in the claims.

The admitted prior art does not teach or suggest a linkage connected to said plane comprising a first mass and a second mass laterally disposed in said plane and constrained to move in opposite directions perpendicular to the plane as recited in claim 1. By constraining the two masses to move in opposite directions, common node rejection is significantly improved.

Shcheglov is directed to a high precision, low noise gyroscope which includes internal radial sensing and actuation. This type of gyroscope is utilized in spacecraft and the like for navigational purposes. The present invention is directed to a high volume, moderately priced sensor for use in an integrated circuit environment.

The combination of the admitted prior art and Shcheglov describes providing an angular velocity sensor having two unconnected and unconstrained masses that are tilted out of phase with each other to provide a higher precision, low noise part. This combination would still have the common node interference problems as noted in the above-identified admitted prior art and furthermore could not be utilized in the same environment as the present invention. Accordingly, Applicant respectfully submits that independent claim 1 is allowable over the cited references. Applicant further submits as to claims 2-47 that they are allowable since they depend from an allowable base claim.

Furthermore, as above mentioned the combined references either singly or in combination neither teach nor suggest the actuation, linkage, etching, and thinning features as recited in the various dependent claims. For example, the cited references neither teach or suggest fabricating CMOS circuitry within the gyroscope wafer as recited in claims 16-18. Integration of the CMOS circuitry within the gyroscope wafer is very important since a high performance gyroscope can be provided because parasitic capacitances caused by interconnects to the circuitry can be eliminated.

Furthermore, in the case of Shcheglov the mass motion is sensed by adding electrodes in a circular beam inside the vibrating mass. The gyroscope wafer in accordance with the present invention is sensing the motion of the mass indirectly through electrodes placed on the wafer under the moving actuators (claim 18). A sensor in accordance with the present invention is significantly easier to manufacture.

Finally, the references neither teach nor suggest the cap bonding which includes a hermetic bond as recited in claims 37-39.

In view of the foregoing, it is submitted that the claims 1-47 are allowable over the cited references and are in condition for allowance. Applicant respectfully requests reconsideration of the rejections and objections to the claims, as now presented.

Applicants' attorney believes this application in condition for allowance. Should any unresolved issues remain, Examiner is invited to call Applicants' attorney at the telephone number indicated below.

Respectfully submitted,
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